

THE
CURE OF STRABISMUS

BY

SURGICAL OPERATION.

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§ 1.—*History and principle of the operation.*

THE fact, that strabismus is not dependent on any organic change in the muscle, *towards* which the eye is distorted, has in all probability been the cause, why dividing the muscle was never put in practice, till recommended by Stromeyer¹, so late as 1838. That, in general, convergent strabismus depends on no change in the structure of the adductor, and divergent strabismus on no change of the abductor, is shown by the motions which the squinting eye performs along with its fellow, and still more strikingly by keeping the squinting eye open, and closing the other; for when this is done, the squinting eye instantly assumes a natural position, and moves from side to side, always with considerable freedom, and often in a perfectly natural manner. The same experiment also disproves the notion, that in strabismus there is a paralytic state of the muscle, belonging to the side *from* which the eye is distorted; and equally sets aside, at least in all ordinary cases of the disease, the hypothesis that the most sensitive part of the retina of a squinting eye is not, as in the retina of a sound eye, the vertex, but some other part, in order to see with which, the patient distorts the eye, till that part receives the image; for we find, in general, that the instant the opposite eye is shut, the squinting eye, under the guidance of its abductor and adductor, points its pupil, and consequently the vertex of its retina, towards the object. An exception to this rule is when a speck of the cornea partially covers the pupil. If there is no such speck, and yet, on shutting the good eye, the squinting one is not turned directly towards objects, but remains distorted, then, but not till then, there will be reason to suspect, that the vertex of the retina of that eye is less sensitive than some part to the side of the vertex. The cause of ordinary strabismus, then, must lie deeper than the muscles of the eye, and deeper even than the retina; namely, in the brain and nerves, the organs which govern the associated actions of the muscles of both eyes. It is, therefore, not to be wondered at, that when the thought occurred to the minds of medical men, as there is reason to believe it did,² that the division of the adductor might perhaps prove useful in convergent strabismus, the plan of thus remedying a disordered exercise of a

nervous function, by dividing one of the muscles, which, in consequence of that disorder, acted abnormally, should have been conceived with distrust, and, till now, allowed to fall aside.

Stromeyer was led to advise a trial to be made of dividing the adductor in cases of convergent strabismus, in consequence of his attention having been directed to the cure of deformities by the cutting across of contracted muscles and tendons. It is plain, that the two cases are not strictly analogous; for the division of a muscle, to free a part which is confined in an unnatural position, such as the head in wry-neck, is an operation somewhat different in principle, from the division of the adductor in convergent strabismus. The latter operation does not sever a contracted indurated muscle, nor liberate the eye from an unnatural position in which it is bound down, but merely abridges the exorbitant activity of one force, in order to allow another force an opportunity of acting.

Stromeyer tried the operation only on the dead body. Pauli³ of Landau was the first to employ it on the living; but in his hands it failed. It was reserved to Dieffenbach, to prove the advantages of myotomy or tenotomy, as it has been called, in the cure of strabismus, which he did, in numerous instances, towards the end of 1839.

§ 2.—*Preliminary examination. Varieties of strabismus. Cases requiring one, and cases requiring both eyes, to be operated on. Prognosis.*

When a case of strabismus presents itself, a number of particulars require to be investigated, before pronouncing a prognosis, or attempting a cure by surgical operation.

1. When the muscles and motor nerves of the eyes are perfectly free from disease, so that there is no strabismus, and the person looks straight before him towards some distant object, the pupil of each eye is placed nearly midway between the nasal and temporal sides of the orbit, and the axes of the eyes are accounted parallel, although they are not strictly so. The distance between the pupils or between the inner margins of the corneæ being measured, if the person now turns his eyes to either side, and towards objects placed at the same distance as the object which he looked at directly, the one eye, by the action of its abductor, becomes everted, and the other, by the action of its adductor, becomes inverted, but the pupils maintain the same relative distance as at first, and the axes of the eyes continue parallel.

Mutual parallelism, then, is the natural condition of the eyes, when directed to distant objects, and as this condition continues even when one eye is blind, it must be independent of vision, and arise from the constitution of the motor nerves.

In strabismus, when the person looks, with both eyes open, at a distant object placed straight before him, one of his pupils is placed in its normal situation, but the other is turned towards the nose or towards the temple. If it is turned towards the nose, the strabismus is said to be *convergent*; if towards the temple, *divergent*. When one or other of the pupils is thus distorted, the axes of the eyes are no longer parallel, but, if continued, would meet and cross each other, *before* the eyes in the convergent variety, and *behind* them in the divergent. This is the case, whether the person looks forward or to either side; for if we measure the distance between the inner margins of the corneæ, whilst the patient is look-

ing at a remote object straight before him, we find it less in convergent, and greater in divergent strabismus than it ought to be, and let the eyes be turned as they may, the same faulty distance continues, and the same want of parallelism consequently continues also.

There is, then, in strabismus, a new and abnormal association of the eyes, a mutual convergence in the one variety, and a mutual divergence in the other. Like parallelism, this new association is shared by both eyes; like it, is unaffected by the state of vision; and like it, continues, whatever be the direction of the object looked at. The one eye may be straight or central, as when the patient looks at an object directly before him, while the other eye is inverted or everted; the one eye may be everted and the other inverted, as in looking to a side; by moving the object to the temporal side of the distorted eye in convergent strabismus, or to its nasal side in divergent strabismus, both eyes will become equally inverted in the one case, and equally everted in the other; yet, the faulty distance between the pupils will continue as before, and consequently, the want of parallelism, and the mutual convergence or divergence, as the case may be, will be unchanged.

In treating of strabismus, we require to distinguish *inversion* and *eversion* from *mutual convergence* and *mutual divergence*. In many cases, both of convergent and divergent strabismus, we observe, that when the patient looks fully to one side, the one eye is inverted, and the other everted. Want of parallelism in the axes of the eyes, and not mere inversion or eversion, is the essential characteristic of strabismus;⁴ and the whole object of the treatment in this disease, is not so much to remove the mere inversion or eversion of the eyes, still less to destroy their power of inversion or eversion, as to restore them to parallelism in all their movements.

When parallelism is lost, it will always be observed, as Mr Elliot⁵ of Carlisle has pointed out, that on desiring the patient to look straight before him, one eye is directed in the natural way, straight upon the object, while the other is inverted or everted, according to the kind of strabismus. The position of the one eye is regulated by the object looked at, and is subservient to its exercise of vision; the position of the other is regulated entirely by the association of motion between the eyes, and does not depend on vision any more than does the position of the blind eye of a person whose eyes are parallel. If the eyes in any case of strabismus are unequal in visual power, the more clear-sighted is always used by the patient in preference to the other, when both eyes are open. The worse eye is distorted, because if used at all, it would supplant the better eye. The patient has no power to substitute the vision of the worse eye for that of the better, when both eyes are open and neither is shaded; and therefore, under such circumstances, the former is always distorted. If the eyes are equal in visual power, they will be distorted alternately, though the mutual convergence or divergence, or, in other words, the faulty distance between the corneæ, will always be the same. In strabismus characterized by mutual convergence, then, when the patient looks forward, one eye must be inverted, and in strabismus characterized by mutual divergence, one eye must be everted, as both eyes cannot be directed straight upon an object, unless their axes are parallel. The relative powers of vision decide as to which organ will be employed, while the other must obey the abnormal association of motion.

Authors speak of *single* and *double* strabismus. To constitute a case

of *single* strabismus, the distortion, whether convergent or divergent, should always appear in the same eye, and not affect the good eye, even on shading it with the hand, while the squinting eye is directed straight towards objects. Such a case rarely, if ever, occurs, unless after operation.

It is a common notion that there is a *double* convergent strabismus, in which both eyes are inverted at the same moment, and a *double* divergent strabismus, in which both are simultaneously everted. A patient, in a fit of musing, or regarding things carelessly, or employing his eyes with rapid alternation, may seem to squint with both eyes, but the moment that his attention is directed to a particular object at a considerable distance, the one eye becomes straight, and the other remains distorted. When the object is very near, both eyes are inverted together, in convergent strabismus. Both eyes might also be inverted under such circumstances as the following, viz:—1st, the vertices of both retinæ being insensible, or, 2d, insensibility of the vertex of the retina of the better-sighted eye, with mutual convergence.

Not unfrequently we meet with cases, in which, both eyes being uncovered, the distortion seizes sometimes the one eye, and at other times the other, the patient using only one eye at a time. Such cases are designated by the name of *alternating* strabismus. The patient possesses the power of directing the eyes alternately upon the object looked at, when both eyes are open, and neither is shaded. Parallelism is equally wanting in these cases as in the others; the eyes are still mutually convergent or mutually divergent, according to the direction of the distortion.

The most common cases of strabismus are, with both eyes open, *non-alternating*; although the distortion can be made to alternate, by shading the clear-sighted eye, and calling the opposite one into action. Whether the disease is convergent or divergent, when both eyes are open, the same eye is always used for the purposes of vision, and the distortion always appears in the other; and hence, one eye only seems to be affected, although both are involved. With both eyes open, and neither of them shaded, the patient is able to direct only one eye, and always the same one, towards the object.

We are able readily to detect non-alternating, as well as alternating, strabismus, by desiring the patient to look steadily, with either of his eyes at any object straight before him, while with our hand we hide the object from his other eye, but keep the hand sufficiently raised towards the temple, to allow us to watch the movements of the eye which is thus shaded. Whether the strabismus is alternating or non-alternating, the shaded eye is distorted.⁶ If, in such a case, we close both eyes, and then suddenly raise the upper eyelid of either, while the other remains closed, the one which is opened is seen to be distorted. If both eyes are suddenly opened, the pupil of the worse eye is discovered to be more distorted than that of the better eye.⁷

If, on trying these experiments, the eye which is shaded, or either of them on being opened suddenly, showed no obliquity, we would pronounce that eye to be sound, and assure the patient that the distortion of its fellow might be cured without operation, simply by exercising the squinting eye, with the other bandaged.

If the shading of either eye makes the other straight, and throws the one which is shaded into distortion, the case is plainly one in which both

eyes are implicated. On again exposing both eyes, the distortion settles as before in the eye whose vision is the more defective, which should therefore be subjected to a division of its adductor or abductor, according as the case is convergent or divergent. Out of a hundred cases of strabismus, five probably are divergent, and the rest convergent. Distortion directly upwards or downwards is very rare. Not unfrequently, in convergent strabismus, the eye is turned upwards and inwards, or downwards and inwards, which might lead us to suppose that besides the adductor, the inner fibres of the levator or depressor would require to be divided. Experience shows, however, that dividing the adductor is generally sufficient.

2. The *degree of distortion* and the *mobility* of the eyes require to be observed.

We meet with cases in which the distortion is slight; others, in which, though greater, it is still moderate, none of the cornea being covered; while in a third set, the cornea is almost completely hid from view, so that the distortion is extreme. Similar gradations occur in respect to the mobility of the distorted eye, when the opposite eye is closed; for, in some cases, the power of turning the eye is perfect; in others, the eye can be brought to the central position, but no farther; while, in a third set, the eye cannot reach the central position, and presents but a very limited power of motion.

The degree of mobility, much more than that of distortion, affects the prognosis; for a great degree of distortion, if the mobility is free, may often be remedied by a simple and easy operation, while a case in which the motion is much impeded, although the faulty direction is trifling, generally requires more trouble to free it from its distorted state, and is less apt to be perfectly cured. The power of abduction being free, in convergent strabismus, indicates that the inversion is principally caused by the adductor, and is not much owing to the action of the levator and depressor.

Mr Elliot's observations show, that, whether the strabismus is alternating or non-alternating, if the distortion is slight, an operation on one eye will generally be sufficient to restore parallelism; but that if it is great, both eyes will often require to be operated on.

In alternating cases, if the distortion is moderate, and the power of inverting and evertting each eye singly is free, the division of the adductor or the abductor of one of them, according as the strabismus is convergent or divergent, is, in general, sufficient. If the distortion is extreme, and the movements imperfect, the operation will require to be performed on both eyes.

With respect to the prognosis in cases where there is no alternation, but where the same eye always squints, and the other is straight, as the patient looks directly before him, with both eyes open, the following facts are established:—

If the bad eye is but slightly distorted, and its power of motion, when the better eye is closed, is free, the cure which is obtained by dividing the adductor or the abductor of the bad eye, according as the case is convergent or divergent, is so nearly perfect, that it is unnecessary to operate on the better eye. But, where the distortion is greater, and the power of motion is less, either the restoration of the bad eye to its natural position is prevented after the operation, or the distortion shifts to the better eye, in consequence of the abnormal association of the nerves

of the two sides. This association is broken, and parallelism restored, by operating on both eyes.

After the first eye is cut, Mr Elliot, by the following simple rule, determines whether the second requires to be operated on or not:—If any distortion be apparent in either eye, on looking straight forward, immediately after the first operation, the second eye should be cut.

It is rather to be regretted that Mr Elliot should have spoken of dividing the adductor of the *sound* eye, after the section of the opposite adductor fails in restoring parallelism, in convergent strabismus. The term is objectionable, because in strabismus, neither eye is sound, although one eye may seem to be so, on examining the patient with both his eyes open. In a written communication with which Mr Elliot has favoured me, in answer to some queries which I took the liberty of submitting to him, on this and some other points, he says, “I have never seen a patient squint with both eyes, at the same time, on looking at an object, placed a few feet straight before him, but have always seen the position of one eye to be perfectly natural. It will always be found, also, that the vision of that eye is the best, so that as far as position, vision, and motions are concerned, it is sound, provided that both eyes be open. The unsoundness consists only in its association of movements with the other eye.” The term *sound*, however, has evidently staggered some with regard to the safety of Mr Elliot’s improvement in the cure of strabismus, and it would be more in accordance with the facts of the case to speak of the *better* eye, or the *clear-sighted* eye, than of the *sound* eye. The first of these expressions, indeed, Mr Elliot makes use of in his last published paper.

Care must of course be taken, not to mistake luscitas for strabismus; lest we fall into the error of dividing the adductor or abductor for a distortion caused by *palsy* of the antagonist muscle, a proceeding which would be useless.

3. The *healthy* or *unhealthy condition of the textures* of the eye should be noticed, and especially the state of the conjunctiva and cornea.

The operation is more difficult of execution, if the eyeball be small and sunk in the orbit, than if it be large and prominent.

If the eyeball be large, it will be less acted on by the inner fibres of the levator and depressor, unless their tendons are broad in proportion, which Mr Elliot has not observed to be the case. In such circumstances, therefore, parallelism of the eyes is likely to be restored by the division of one adductor.

If the eye has at any period suffered much from inflammation, which is sometimes evident from specks on the cornea, and in other cases from the conjunctiva, especially at the inner angle of the eye, appearing darker, drier, thicker, and less moveable than natural, there is a probability that the conjunctiva and the structures which lie between the conjunctiva and the sclerotica are unnaturally adherent, a circumstance which is apt to render the operation tedious, and less successful. A squinting child, being seized with scrofulous ophthalmia, is very likely to have the eye fixed in the inner canthus by adhesion of the subconjunctival textures, till on the inflammation subsiding, and the eye becoming again capable of being used, the unnatural connexions are gradually elongated into cellular bands, by the action of the abductor.⁸

A speck on the cornea of a squinting eye is no objection to the operation, provided the other eye is the better of the two; but if the squinting

eye is that on which the patient chiefly depends for vision, the distortion may be an instinctive provision, by which he sees more than he could do, were the eye straight. In such a case, to cure the strabismus might be the means of materially abridging the range of vision of the eye, and ought therefore to be avoided.

Alternate strabismus may be a means, when both corneæ are partially opaque, of permitting the rays of light to penetrate through the clear portions of the corneæ, and thus reach the retinæ. Were the strabismus in such a case cured by an operation, an artificial pupil in each eye might be required, before the former degree of vision could be regained.

4. The *extent* and *acuteness of vision* of each eye separately, and of both together, should be carefully examined before proceeding to the operation, in order that we may be able afterwards to form a correct estimate of its effects.

The vision of a squinting eye is, in general, defective, so much so that the patient can seldom read an ordinary type with it. In some cases, it does not serve him to read a large type, nor even to know one person from another. There is reason to believe, that the vision of the one eye being so much more impaired than that of the other, often originates in the wearing of a shade over that eye. The imperfect vision occurs about the same time as the mutual convergence, but does not cause it. "Reflex or sympathetic irritation of the nerves of the third pair," says Mr Elliot, in his letter to me, "by causing an increased action of the muscles which they supply, gives rise to the mutual convergence, or new moving association; and as the mutual convergence prevents the directing of both eyes on the same object at the same time, the clear-sighted eye will obey the will of the patient, while the other is subservient to the moto-nervous connexion of the two organs."

In non-alternating cases, it is generally possible to remove the distortion from the better eye to the worse, by bandaging the former, and thus improving the vision of the latter by use.

In some rare instances, a part of the retina to one side of the vertex is more sensible than the vertex itself. When this is the case, the distorted eye remains so, although the opposite eye is closed, and the patient regards an object straight before him; but on moving the object to one side, the distorted eye becomes straight.

Occasionally the distorted eye is completely amaurotic; and in this case, the operation must be regarded merely as a means of improving the patient's appearance.

In alternating strabismus, the vision of the two eyes is about equal. In strabismus, without alternation, the degree of distortion and the inferiority of vision of the worse eye are generally proportionate. The eye whose vision is the more imperfect is always to be chosen as the subject of operation.

When the vision of both eyes is good, but the convergence great, two operations will be required. The convergence being slight, although the vision of the worse eye is very bad, one operation will be sufficient. Limited abducting power and smallness of the eyeballs are more likely to render necessary the division of the second adductor, than any state of the vision.

5. The *date*, *permanency*, and *exciting cause* of the strabismus should be inquired into.

There are children, and even adults, who occasionally squint, but can

prevent the distortion when on their guard. A recent and transient strabismus is not unfrequently the result of intense use of the eyes, mental agitation, or irritation communicated from the abdominal viscera to the brain. Such cases should be treated with rest, purgatives, tonics, and proper exercise of the eyes. It is only when strabismus has continued for a considerable length of time, generally for years, and has attained the character of being *confirmed*, that we should think of remedying it by operation.

In a valuable analysis of 200 cases of strabismus, Mr Radclyffe Hall⁹ enumerates the following causes as those assigned by the patients themselves or their parents, without vouching for the correctness of the testimony, except where physical conditions yet remained to substantiate the opinions given.

“ 1. Convulsions during infancy, in 9 cases ; falls on the head, in 7 ; severe concussion of the brain, in 1 ; difficult dentition, in 3 ; hooping-cough, in 2 ; intestinal worms, in 3 ; epilepsy, in 2 ; a severe thrashing, in 1 ; excessive fright, in 1.

“ 2. Ophthalmia which had left no opacities, in 14 ; opacity of the cornea, in 5 ; opacity said to have existed formerly, in 1 ; wound of the cornea, by a stocking needle, in 2 ; by a fork, in 1 ; by a thorn, in 2 ; blow on the eye, in 5 ; burn of the eye from a piece of metal flying into it, in 1 ; a habit of looking at the sun, in 2 ; crush from a cart-wheel going over the orbit, in 2 ; amaurosis, in 2 ; imperfect cataract, in 3 ; exposure during infancy to the light and heat of a blazing fire, in 3.

“ 3. Imitation of a squinting person, in 39 ; watching the motion of a shuttle, in 1 ; voluntarily trying to squint, in 1 ; a habit of looking at a scar on the eye-brow, in 1 ; at a scar on the nose, in 2 ; at a scar on the cheek, in 2 ; at a small encysted tumor at the inner canthus, in 1 ; at a small nævus in the same situation, in 1 ; at a mole on the nose, in 1 ; a habit of sucking the thumb, and looking steadfastly at it, at the same time, in 1 ; holding the head sideways whilst knitting, in 3.

“ 4. Measles, in 4 ; small-pox, in 6.

“ 5. Severe burns of the abdomen, in 2.”

In four instances, Mr Hall was assured that the strabismus was congenital. In the remaining cases of the two hundred, no causes were assigned.

Mr Hall's remarks on the different classes of causes are highly judicious.

It appears probable, that in the 1st and 5th classes, an unequal communication of nervous energy to the muscles of the eye, in consequence of disease in the brain or its vessels, is the origin of the distortion. In the 2d and 4th classes, the distortion is probably at first an effort to free the eye from pain, or the result of such disuse of the eye and of its natural movements, as must often arise from wearing a shade over one eye. In the 3d class, strabismus arises from habit.

In the early stage of every strabismus, double vision must exist. An effort to free the vision from the confusion, attending diplopia, probably increases the distortion. As the disease becomes confirmed, the vertex of the retina of the squinting eye, being no longer turned towards objects, and therefore receiving only the light which falls upon it obliquely, seems to lose a great share of its sensibility, merely from disuse.

In all the five classes, strabismus, having once become habitual, so that one of the muscles of the eye is almost always in a state of active contraction, while its antagonist is left in a state of relaxation, the former not only obtains an increase of power at the expense of the latter, but there is reason to think that interstitial changes sometimes take place, by which the active muscle may become hypertrophied, and the inactive one wasted. The process by which such a condition of the parts can be

brought about, must be slow, and can occur only where the strabismus has continued for years, with little or no intermission. Were such a state of the muscles known to exist in any case, it would lead to an unfavourable prognosis in regard to the result of the operation.

§ 3.—*Parts implicated in the operation.*

The muscles of the eye, like all other muscles, are enclosed each in its own cellular sheath.

If we remove the loose cellular tissue which lies immediately beneath the conjunctiva, a thin condensed layer of the same substance is found covering the external surface of the tendons of the recti, and connecting them together. This layer constitutes the *subconjunctival fascia* of Mr Lucas,¹⁰ who observes that although exceedingly delicate, it is sufficiently strong to offer considerable resistance, as is experienced in passing the blunt hook under the tendon of one or other of the recti, in the operation for strabismus. In some subjects, this fascia is much stronger than in others. The subconjunctival fascia is a continuation of the *cellular capsule* of the eyeball, described by Tenon, Bonnet, and Ferrall.

Tenon,¹¹ in a paper read to the French Institute in 1804, described the eyeball as enclosed in what he styles a *new tunic of the eye*, adhering to the optic nerve, where it penetrates the sclerotica, and forming a membranous envelope round the eyeball. He stated that it afforded passage to the tendons of the recti and obliqui, and served to suspend the eye in the orbit, and to connect it with the eyelids. It is this structure which M. Bonnet¹² of Lyons has recently described as a *capsule* for the eye, and for which Mr Ferrall¹³ of Dublin has proposed the name of *tunica vaginalis oculi*. Both these authors, (the latter without knowing of Tenon's description,) insist particularly on the structure in question serving to exclude the eyeball from the fat of the orbit, and forming a smooth hollow surface by which the motions of the eye are facilitated. Mr Ferrall has contributed some important views regarding the pathology of the capsule, and has pointed out the best mode of displaying it in the dead body, which is to divide each eyelid vertically in its middle, turn the four flaps back, divide the conjunctiva all round at its angle of reflexion, and then with a probe separate the cellular tissue which connects the eyeball to the capsule. Without any farther division of parts, the six muscles are seen perforating the capsule, to reach the eyeball.

In this mode of displaying the capsule, it is brought into view as far forward as the angle of reflexion of the conjunctiva. According to Bonnet, the conjunctiva establishes a circular connexion between the eyeball and the capsule. Tenon, Bonnet, and Ferrall, all trace the capsule into the eyelids. Tenon and Ferrall say it goes to the tarsi. Without denying this, it is, I think, certain, that the thin cellular web, described by Mr Lucas under the name of the *subconjunctival fascia*, is also a production of the capsule, so that this membrane, having reached the angle of reflexion of the conjunctiva, may be regarded as splitting into two laminæ, the one continued into the eyelids, and the other advancing towards the cornea.

When we display the capsule in the mode recommended by Mr Ferrall, it is chiefly the tendinous portions of the muscles, with very little of their fleshy bellies, which are brought into view. The external surface of the

tendons is adherent to the anterior portion of the capsule, or subconjunctival fascia, and their internal surface is similarly connected to the sclerotica. The degree of adhesion varies remarkably in different subjects. In the normal state, it is very loose.

If inflammation has rendered the parts around a distorted eye unnaturally adherent, it is exceedingly probable that after one of the recti has been divided, the distortion may continue, till the morbid adhesions of the tendon are separated, so that it is freed from that portion of the capsule constituting the subconjunctival fascia externally, and from the sclerotica internally; and that as far back as the aperture by which the muscle traverses the capsule.

The anatomy of the capsule being understood, the following particulars regarding the recti deserve attention:—

1. The adductor and abductor are inserted symmetrically, in the same horizontal line.

2. The levator and depressor are not inserted symmetrically, nor in the same vertical line; for the depressor is inserted exactly in the middle line of the eyeball, while the levator is considerably nearer the nose than the middle line of the eyeball. To this circumstance are we to attribute the tendency, so frequent in convergent strabismus, of the eye to turn upwards and inwards?

3. The adductor is the thickest and shortest of the recti.

4. The abductor is the longest, and next to the adductor in thickness.

5. The adductor and abductor are inserted concentrically to the edge of the cornea.

6. The depressor is not inserted concentrically to the edge of the cornea, and the insertion of the levator is placed still more obliquely in respect to the edge of the cornea.

7. The breadth of the tendon of the levator, and that of the tendon of the depressor, at their insertions, is about $\frac{7}{20}$ inch.

8. The breadth of the tendons of the adductor and abductor, at their insertions, is about $\frac{8}{20}$ inch.

9. The length of the tendinous portion of the levator, depressor, and adductor, is $\frac{3}{20}$ inch; the length of that of the abductor, $\frac{6}{20}$ inch.

10. The following are the distances at which the tendons are inserted from the cornea:—

	Adductor.	Abductor.
Insertion of centre of tendon, .	$\frac{4}{20}$ inch.	$\frac{5}{20}$ inch.
— superior edge of tendon, .	$\frac{6}{20}$ "	$\frac{7}{20}$ "
— inferior edge of tendon, .	$\frac{6}{20}$ "	$\frac{7}{20}$ "

	Levator.	Depressor.
Insertion of centre of tendon, .	$\frac{7}{20}$ inch.	$\frac{5}{20}$ inch.
— inner edge of tendon, .	$\frac{6}{20}$ "	$\frac{5}{20}$ "
— outer edge of tendon.	$\frac{8}{20}$ "	$\frac{6}{20}$ "

§ 4.—Instruments necessary for the operation.

The tendon of any of the recti might be divided in many different ways.

A fold of conjunctiva, over the tendon of the adductor, for example, might be raised with a dissecting forceps, the fold divided by the stroke of a small scalpel, and, by another stroke or two, the tendon, thus exposed, might be cut across.¹⁴

A small snip being made through the conjunctiva, opposite to the lower edge of the adductor, one blade of a pair of scissors might be pushed up behind the tendon, the scissors closed, and the tendon and conjunctiva divided at once.¹⁵

M. Guerin's operation is said to be subconjunctival.¹⁶ He pushes, I suppose, a narrow knife through the conjunctiva, and between the tendon and the sclerotica. Then turning the edge of the knife towards the tendon, he divides it, leaving the conjunctiva by which it is covered entire.

The danger that the sclerotica might be opened in such modes of operating, especially were the operation attempted by an inexperienced hand, is sufficiently obvious; and, therefore, a safer, although a little more operose, plan of proceeding ought to be adopted.

The instruments more immediately necessary for the operation, are:—

1. A small dissecting forceps, or toothed forceps, such as that represented in *fig. 26*, of my Practical Treatise on the Diseases of the Eye.

2. A pair of small, straight, blunt-pointed scissors, which cut perfectly.

3. A blunt hook, about $\frac{1}{40}$ inch thick, and the bent part $\frac{9}{20}$ inch long.

4. A fine sharp hook, such as is commonly contained in cases of eye-instruments.

Wire specula, the part which presses on the eyelid being concave instead of convex, are sometimes used for retracting and fixing the eyelids; but the fingers of an assistant produce less uneasiness to the patient, and do not interfere so much with the manipulations of the operator.

A small bit of sponge, with cold water, should be at hand.

§ 5.—*Position of the patient and assistant.*

If the patient is an adult, he should be placed on a seat without a back so that he may lean his head on the breast of an assistant standing behind him. If the patient possesses ordinary command over the muscles of the squinting eye, when the opposite eye is closed, so that he can turn it considerably from its distorted position, and keep it so, one assistant may be sufficient; but if he cannot do this, a second assistant is necessary. If the patient is a child, more assistants than two may be required; and the patient, being wrapt in a sheet, so that his arms and legs are kept at rest, is to be laid on a table, with his head on a pillow.

§ 6.—*Operation.*

The opposite eye being covered with a compress and roller, an assistant standing behind the patient, with the fore-finger of one hand raises the upper eyelid, and with that of the other depresses the lower.

The operator, standing before the patient, desires him to turn his eye, as much as he can, in the direction which puts on the stretch the muscle about to be divided. If the case is one of convergent strabismus, he desires

him to look outwards, to his temple; if it is one of divergent strabismus, he desires him to look inwards, to his nose.

We shall suppose the case to be one of convergent strabismus. The reader will easily conceive that many of the observations which occur in these pages regarding the cure of convergent strabismus, may be applied to that of the divergent variety, by substituting *abductor* for *adductor*.

The steps of the operation, then, are as follows:—

1. With the forceps, the operator lays hold of the conjunctiva transversely, midway between the edge of the cornea and the caruncula lacrymalis, and raises it in a horizontal fold.

2. With the scissors, he snips this fold through vertically, along with the subjacent cellular substance, and then enlarges the incision, thus begun, upwards and downwards, so that it extends to half an inch in length.

The incision should not be nearer the cornea than half-way between its edge and the caruncula, lest in attempting to pass the blunt hook under the tendon, the operator find it impossible to do so, from the close attachment of the tendon to the sclerotica; nor ought it to be farther from the cornea, else the operator will require to penetrate deep by the side of the eyeball, to reach the muscle.

The conjunctiva is merely to be slit up to the extent specified; it is not to be dissected from the subconjunctival fascia, nor is any portion of it to be cut away. In this way the wound will heal more readily, and the eye be less apt to protrude after the operation.

The incision of the conjunctiva is generally made in a vertical direction. In operating for divergent strabismus, it appears to be Mr Elliot's plan to open the conjunctiva horizontally. Perhaps the incision made in this direction will gape less than a vertical one, but more separation of the membrane from the subjacent fascia will be required, to bring the tendon into view. A frænum will also be apt to form between the cicatrice of the conjunctiva and the external canthus.

3. The patient again evertting the eye as much as he can; and the parts, if obscured with blood, being sponged, the operator insinuates the point of the blunt hook under the lower edge of the tendon of the adductor, and slides it up between the tendon and the sclerotica, till its point appears above the upper edge of the tendon, as is represented in the annexed figure. If there is any difficulty in bringing out the point of the hook at the upper edge of the tendon, from its carrying the fascia before it, the operator snips this through with the scissors, and frees the point of the hook.

In this part of the operation, unless the incision be nearer than usual to the cornea, or the operator take the trouble of removing a portion of the fascia, it is rarely the case that the fibres of the tendon are distinctly perceived. They are obscured by the fascia, which is now generally injected with blood. The operator, therefore, introduces the point of the hook where he thinks the lower edge of the tendon should be, and pressing it close along the surface of the sclerotica, he takes up on the hook everything that lies between the sclerotica and the surface exposed by the incision of the conjunctiva. The hook, entering the cavity of the capsule, where the cellular connexion of the tendon to the sclerotica is naturally very loose, is easily passed beneath the tendon. This part of the operation, therefore, gives little pain, unless the hook is not suf-

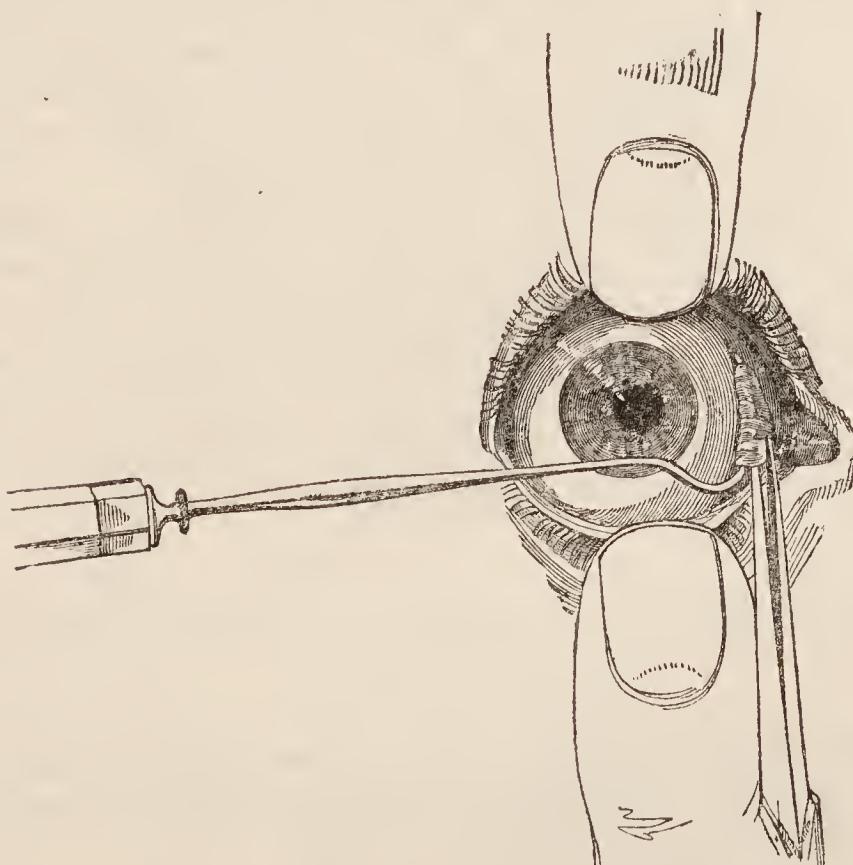
ficiently bent, or the bent part too long, so that it must be brought out over the eyelids, and by putting the muscle on the stretch, drag severely on the eyeball.

It is seldom that the patient is unable to evert the eye sufficiently, to allow the first and second steps of the operation to be performed, with no further assistance than what has now been mentioned; but it sometimes happens that he cannot continue the eversion, at least to the necessary degree, to permit of the third step. In this case, the operator lays hold with the sharp hook, of the tunica tendinea, or, in other words, of the tendon of the muscle, where it is exposed through the incision of the conjunctiva, and without passing it deeper than the surface of the sclerotica, he moves the eye into the everted position. This he effects with a very slight degree of traction. He then intrusts the sharp hook, thus fixed, to an assistant, and proceeds to pass the blunt hook.

If artificial eversion is called for at the commencement of the operation, which sometimes is the case, especially in children, the operator passes the sharp hook through the conjunctiva and into the tunica tendinea, about one-fifth of an inch from the inner edge of the cornea, and having drawn the eye into the position required, intrusts the sharp hook to an assistant, till the first, second, and third steps of the operation are completed. After the blunt hook is passed under the tendon, the sharp hook may be removed.

At whatever step of the operation the sharp hook is used, it must be fixed in the tunica tendinea. It is useless to fix it in the conjunctiva; as this membrane, when we endeavour to move the eye by traction on the hook, yields, and slides away from the subjacent textures. To penetrate through the sclerotica with the sharp hook, is unnecessary.

4. The operator now takes the blunt hook in his left hand, and car-



rying the handle of it towards the temple, with the scissors he immediately divides, in ordinary cases, the tendon of the muscle from below upwards, and nearer the caruncula than where it is over the hook. (See the above figure.)

In this manner of operating, the muscle will most frequently be divided just where the tendinous part meets the fleshy fibres.

If the distortion is slight, the handle is to be carried over the nose, and the tendon divided nearer the cornea than where it lies over the hook, and close to its insertion.

If the distortion is great, the operator, before proceeding to use the scissors, should separate a considerable portion of the internal surface of the muscle from the sclerotica. Dr Ammon¹⁷ does this by pressing the blunt hook repeatedly towards the cornea, and back again towards the caruncula. Mr Elliot,¹⁸ for the same purpose, introduces a second hook, and steadies the eye by means of the one already under the tendon. The tendon being then drawn into view, the muscle is to be divided. If hypertrophied, a part of it should be cut out, which is best accomplished by passing a ligature under it with a blunt needle, tying the ligature upon the muscle, dividing the latter nearer the caruncula than where it is within the ligature, and lastly, cutting off the ligature, with the portion of the muscle which it embraces.

If, in the third step of the operation, only a portion of the tendon, and not its whole breadth, appears to be upon the blunt hook, the division with the scissors should not be immediately proceeded with; but, with another and smaller blunt hook, the operator should take up the remaining breadth of the tendon, and having divided this portion with the scissors, proceed to divide the principal portion, which he has on the first hook. It must be remarked, however, that when the tendon is raised and drawn forwards on the concavity of the blunt hook, it sometimes assumes a round and contracted appearance.

If the operator has any doubt about his having divided the whole of the muscle, he should not proceed to ascertain the position of the eye, and much less inadvertently announce to the patient that the operation is finished, until he has examined with the blunt hook, and snipped across any portion which may have escaped. The mark of the semicircular insertion of the muscle, with its minute tendinous fibres, adhering to the sclerotica, will show distinctly that the muscle has been divided.¹⁹

Such, then, is the operation for convergent strabismus. That for the divergent variety is generally considered rather more difficult, owing to the greater narrowness of the space between the eyelids, and the insertion of the abductor being farther from the cornea than that of the adductor. As to this, a good deal will depend on the size and prominence of the eye.

Upon the same general plan, the levator or depressor is to be divided, in cases of distortion upwards or downwards.

§ 7.—*Immediate effects of the operation on the relative positions and motions of the eyes.*

If the adductor or abductor has been divided, certain effects are immediately produced on the mobility of the eye which has been operated on, and on the relative position of the two eyes.

1. The compress and roller being removed from the opposite eye, the patient finds that he can turn the eye which has been cut, fully and with a feeling of freedom, towards the temple or towards the nose, according as the adductor or abductor has been divided. This, which he could not do before, is a proof that the tendon has been fairly divided. If he can-

not turn the eye freely, there is reason to suspect that the tendon has not been completely divided, or has not been sufficiently separated from the sclerotica.

2. When the patient looks directly before him, and the operation is complete and successful, the distortion which previously existed is removed, and the optic axes are parallel. In some cases, they retain their parallelism when he turns his eyes to the right, if the right adductor or left abductor has been divided, or towards the left, if the left adductor or right abductor has been the subject of operation. On closing the eyes, and suddenly raising first the upper lid of the one, and then that of the other, the opposite eye being kept shut, there is no distortion to be seen in either. The operation on one eye has removed the mutual convergence, and restored parallelism.

After the division of one adductor, the eye may be observed occasionally inverted. If, on closing the clear-sighted eye, the inverted one becomes straight, and on raising the lid of the closed one, both eyes are straight, there is evidently no remaining mutual convergence, and by exercising the eye which has been operated on, the other being bandaged, the cure will be established, without further operation.

3. It is generally believed, that when the operation is complete, and promises to be successful, the eye has lost the power of being turned into the inner canthus, when the adductor has been cut, or into the outer canthus, when the abductor has been divided. It has also been stated, but there is reason to believe upon still more insufficient grounds, that, after the adductor has been cut, if the patient retains the power of turning the eye nearer to the nose than the centre of the orbit,²⁰ either in a horizontal or an oblique line, the operation has not been completely performed, or is not going to effect an immediate cure. In the great majority of cases, it will be found, that the eye can be inverted considerably beyond the centre, but not so much as to conceal the inner edge of the cornea. This remaining power of inversion is commonly ascribed to the action of the internal fibres of the levator and depressor; but M. Bonnet is of opinion, that the motion arises from the connexion still subsisting between the divided muscle and the capsule, the muscle continuing to act on the capsule, and thence, meditately, transmitting its influence to the eyeball. Mr Elliot mentions to me, that on dividing both abductors, he has always found the power of eversion of each eye to be natural, immediately after the operation.

If the patient, after the adductor has been divided, retains the power of turning the eye into the inner canthus, so as to conceal the whole of the white of the eye internal to the cornea, the operator, replacing the compress and roller over the opposite eye, should immediately proceed to examine with the blunt-hook, whether any portion of the tendon has escaped division, as is very apt to happen at its lower or upper edge, or whether the internal surface of the muscle is still adherent to the sclerotica, or is bound to it by any adventitious connexion. Any such undivided portion of the tendon, or unnatural bands of attachment are to be drawn into view with the hook, and snipped through. If this is still insufficient, the external surface of the tendon should be examined in the same manner, and its cellular union to the fascia should be separated, so that the tendon may lie loose and unattached, as far back as the aperture by which it traverses the capsule, which is about $\frac{1}{2}$ inch.

4. It is often the case, (§ 2), that, notwithstanding the complete division of the tendon, and its being carefully separated from its cellular attachments, the distortion still continues, without any, or with merely a slight diminution.

At one period, the general opinion of operators regarding such cases appears to have been, that the disease was confined to the worse eye, the better eye being so little affected as to pass for being sound, and that the want of success attending the division of the adductor was to be remedied by dividing the levator or depressor,²¹ or one or other of the obliqui.²² Farther experience, however, has shown that any interference with these muscles is unnecessary, if the adductor be carefully examined, and liberated from the adventitious adhesions by which it is often tagged to the neighbouring parts.

Another notion, at one time pretty general, was, that although the original distortion should still remain in some degree after the adductor was divided, the operation was not to be immediately deemed a failure. It was urged, especially if the patient, previously to the operation, had been unable to bring the pupil to the central position, that the abductor might require some time to recover its contractile power, so that hours, or even days, might elapse before the eye reached the centre of the orbit, although ultimately a perfect cure might be obtained.

This gradual amendment is not to be trusted to. On the contrary, an eye that is not placed in the centre of the orbit, at the termination of the operation, rarely, if ever, assumes of itself that position afterwards, but generally becomes worse.²³ It is not, however, by making a clean dissection of the whole nasal side of the sclerotica, nor by dividing other muscles than the adductor, that the rule is to be fulfilled, *always to leave the eye straight.*

Mr Elliot, from a careful consideration of cases in which the division of the adductor of the inverted eye failed in removing its distortion, concluded that the disease could not be regarded as confined to one eye, since, when the better eye was closed, the worse one, after the operation as well as before it, became straight, while on raising the lid of the better eye, it was found inverted, though the position of the eyes instantly became reversed, when both were opened. The simple experiment of closing the better eye after the operation, shows, by its rendering the worse eye straight, that the remaining distortion which is seen in the worse eye when both are open, does not depend on any shortening of the fibres of the levator, depressor, or obliqui, requiring that they should be cut, or on any semi-paralytic state of the abductor, from which it may slowly recover, but on the original cause of the disease—a morbid action of the motor nerves.

In such cases, then, of mutual convergence, in preference to the division of the levator or depressor, which, though it might restore parallelism, would leave the eye prominent and limit its future movements, and in place of trusting to exercise of the eyes, which, though it might succeed in some instances, after a practice of weeks or months, in rendering the first eye straight, would fail to do so in those cases where, from various causes, such as a speck of the cornea, partial cataract, or insensibility of the vertex of the retina, the vision of the eye was incapable of being much improved by exercise, Mr Elliot had recourse to the immediate division of the same muscle of the opposite eye; and with signal success. To

estimate fully the merits of this improvement, which certainly in importance stands next to the original invention of the operation, the reader should study with care, the cases detailed by Mr Elliot, in his paper in the Edinburgh Medical and Surgical Journal, already referred to.

5. It sometimes happens, that the inversion is instantly removed from the worse eye, as soon as its adductor is divided, and appears, though not in the same degree, in the other eye; or, when the strabismus is divergent, the eye operated on becomes straight, and the other everted.

Mr Elliot has fully established the immediate division of the same muscle of the eye to which the distortion has shifted, as the means of rendering the eyes parallel in such cases.

Whether the strabismus, then, be convergent or divergent, when the division of the adductor or abductor, as the case may be, of the worse eye, fails to restore parallelism, the distortion either remaining in the eye which has been operated on, or shifting to the other, in consequence of continued mutual convergence or divergence, it is a general rule, that the same muscle of the better eye should be divided.

Parallelism, in such cases, will never be perfectly restored, by any other means. By waiting, before cutting the second eye, and exercising the one which has been operated on, the inversion or eversion of the latter may be removed, but it will be at the expense of the former, which will become inverted or everted. Besides, it is desirable to operate on both eyes, as this plan, when properly managed, always effects the best cure.

In operating on the second eye, it is generally sufficient merely to divide the tendon, close to its insertion, without interfering at all with its cellular attachments. This caution is necessary, lest by separating the surfaces of the tendon from the capsule and sclerotica, eversion of either eye might follow. This cannot happen, if the distortion is mutual, till the inversion of the first eye be removed. If a mere division of the tendon does not remove the convergence, the blunt hook should be re-introduced, and the muscle separated from the eyeball, to the necessary extent. It is generally the case, however, that the instant the second adductor is divided, the eyes become parallel.

It is probable that the true explanation of the fact, that a great number of those who have been operated on for strabismus still squint, is, that the mutual affection of both eyes has been overlooked, and only the worse eye operated on. Dr Lietch,²⁴ with an experience of 264 cases, states that the operation "often affords very satisfactory results," which very moderate testimony in its favour, ought probably to be attributed to the cause now mentioned.

Mr Duffin's account of the effects of the operation for divergent strabismus, is still less encouraging. He states that the eye does not start into its place as soon as the abductor is divided, but requires several days, in some instances, before it is re-instated; and, that although a considerable improvement takes place, the cure is very seldom perfectly successful. "The capability of moving the eyes towards the nasal canthus, by an effort of the will, remains," says he, "precisely the same as before. Nothing has been gained in this respect; the patient has not acquired the power of directing both eyes inwards simultaneously. In fact, all the apparent advantage obtained is, that, when quiescent, the pupils of both eyes occupy the visual axis of their respective orbits, instead of only one doing so, while the other is directed outwards."²⁵

Such, undoubtedly, will generally be the state of matters, after an ope-

ration on one eye only, for mutual divergence. In Mr Elliot's hands, cases of divergent strabismus, by the division of both abductors, have been perfectly cured. I have had the pleasure of examining one of his patients, who had been affected with divergent strabismus for thirty years, in whom the cure is perfect; every movement of the eyes, and even their convergence on viewing near objects, being completely natural.

6. Immediately after the adductor is divided, the abductor sometimes acts too powerfully, and turns the eye towards the temple, but in two or three days the eye generally resumes its proper position. The eversion, in such cases, is attributed by M. Bonnet to too free a dissection of the conjunctiva; but it is probable that it arises oftener from too much separation of the tendon from the sclerotica, in cases of moderate distortion.

7. In a case, related by Mr Duffin, in which the distortion was inwards and upwards, the effect of dividing the adductor was, that the eye turned directly upwards, requiring the levator to be cut across.

§ 8.—*Wound.*

1. In general, only a few drops of blood are lost in the operation. If the incision of the conjunctiva is nearer the caruncula than the distance already specified, (§ 6), the conjunctiva extensively separated from its connexions, or the fleshy part of the muscle divided, the haemorrhage may be more, but is scarcely ever such as to impede the operation.²⁶

2. The pain which attends or follows the division of one of the recti is generally inconsiderable. It is rare to find that the eye becomes intolerant of light, or affected with burning heat or inflammatory throbbing.

3. The edges of the wound of the conjunctiva come together of themselves, in the motions of the eye; and any serous or sanguineous infiltration under the conjunctiva is, in general, slight.

The wound never heals by the first intention, but it rarely suppurates. Lymph is effused between its edges, and it generally closes in a fortnight, or three weeks. In some cases, however, the lips of the divided conjunctiva become swollen, red, and elevated; and this state must subside, before the wound heals. Occasionally the lip next the caruncula, or the subjacent surface, throws out a fungus, which hangs by a pedicle, and may grow to the size of a pea. The application of caustics to the fungus is of little or no use. It is better to lay hold of it with the forceps, and snip it off with the scissors. Should it grow again this must be repeated. The wound which has become fungous takes generally several months to heal perfectly.

4. In one instance only, have I seen severe inflammation attack the eyeball, after the operation for strabismus. Called into consultation in this case, I was informed that the adductor had been divided without difficulty, twelve days before, but that the patient had conducted himself imprudently, and had caught cold. I found the eye turned towards the temple, with much swelling and inflammation at the inner canthus. The sclerotica had already sloughed to the extent of about $\frac{1}{3}$ inch in diameter, so that the choroid, covered by a lymphatic exudation, protruded. Ulceration was extending to the nasal edge of the cornea; the pupil was clear and small. In a few days, the choroid gave way by a minute opening, and allowed the vitreous humour to drain out of the eye. At my

third visit, the eye was in a state of total exophthalmia, tense and much protruded, and the cornea disorganized. Ultimately, the eye shrunk. The patient was bled at the commencement of the inflammatory symptoms, leeched, and mercurialized. Latterly, opiates and poultices were used.

§ 9.—*After-treatment.*

1. Were there much danger of re-action after the operation, we might be induced to put the patient to bed, directing him to keep his eyes shut, and the one operated on covered with cold wet cloths. So little, however, is the tendency to re-action, that labouring people not unfrequently tie up the eye with a handkerchief, and with the aid of the other eye resume their usual employment the day after the operation, without experiencing any bad effects. There seems even a danger in keeping both eyes constantly shut, after an operation for convergent strabismus; for, as in that state they turn upwards and inwards, the operated one must approach its former position, the consequence of which might be that the muscle, by adhering to the sclerotica too far forwards, would cause the distortion to return to a certain extent, as soon as the process of healing was complete. The danger of such an event would be lessened by the patient's employing even the opposite eye, and still more certainly, by using both eyes, within doors, and under the cover of a shade. A green veil is very convenient, affording warmth, excluding too much light, and allowing a free use of the eyes.

The advice commonly given is, that with the opposite eye tied up, the patient should use the operated one, and turn it frequently in the direction opposed to the former distortion; to the right, if the right adductor has been divided, and *vice versa*. The exclusion of the opposite eye, however, if it has not been operated on, only indulges the inclination it already has to squint, and the turning of the eyes to the right, if the right adductor has been divided, favours a continuance of mutual convergence. In fact, the opposite direction rather should be given to the eyes, so as to make their axes diverge, and not converge. After the abductor is divided, the patient should look to neither side, but direct his eyes straight before him, or even towards small objects, placed a few inches from his nose, so as to make the eyes converge.

2. Three or four times a day, the eye should be fomented with warm water, or decoction of poppy heads.

3. The patient should eat no flesh, nor take alcoholic drinks of any sort.

4. He should avoid going out of doors with the eyes uncovered, overheating himself, exposing himself to cold, or looking intently upon minute objects, as in reading or writing.

5. Puro-mucous inflammation of the conjunctiva supervening, is to be treated with the usual remedies for catarrhal ophthalmia.

§ 10.—*Pathology of strabismus, as illustrated by the operation.*

A question naturally occurs, What light has the operation thrown on the pathology of the disease?

1. In general, the muscle which is exposed and divided appears quite natural, in colour, consistence, and insertion.²⁷
2. In some instances, the muscle has appeared in a thickened state, and rounder than natural, has bled more than usual, has been more difficult to divide, and more tendinous than common—in a word, hypertrophied.²⁸
3. In a few instances, it has been atrophied.²⁹
4. The conjunctiva and subjacent textures have not unfrequently been found, especially at the inner canthus, unnaturally adherent;³⁰ sometimes thickened, contracted, and infiltrated to such a degree that they felt like cartilage under the scissors.³¹
5. Irregular attachments of the muscle have been met with, its insertion being farther back than common, and bundles of fibres inserted behind the proper tendon.³²

§ 11.—What becomes of the divided muscle?

Whether it be the tendon or the fleshy part of one of the recti which is divided, the muscle will be drawn back within the capsule; and even the fleshy part, which lies behind the capsule, will suffer a degree of retraction. After a time, the muscle will become re-attached to the sclerotica, by cellular adhesions.

Dr Ammon states that when the tendon is separated from the sclerotica and cut through, the muscle retracts less than when the fleshy part is divided. If the fleshy part is divided, or a piece of it cut out, the muscle contracts so as to become round and narrow; and the space left between the cut surfaces fills with blood, which also surrounds the divided ends. By and by, coagulable lymph is effused. Sometimes the wound heals speedily, the muscle re-uniting, and a firm mass, of a dark colour, small and round in comparison with the original structure, occupying the space between the divided ends. The muscle, in this state, is described by Dr Ammon, as presenting the appearance as if it had been tied for some time with a ligature. In other cases, the ends do not re-unite, but become firmly adherent to the sclerotica, and to the capsule.

The degree of retraction, which the divided muscle undergoes, varies in different cases, and consequently the place of its adherence to the sclerotica varies. Bernoulli³³ calculated that the greatest contraction of the recti, in the natural motions of the eyes, equalled very nearly one-fifth of their length. If this degree of contraction takes place after one of these muscles is divided, the divided ends will be separated more than $\frac{1}{4}$ inch from one another, and the point of re-adhesion to the sclerotica will be behind the transverse diameter of the eyeball. When the conjunctiva and subjacent textures are in a natural state, and the motions of the eye free, the muscle will contract to at least a fifth of its natural length, but where inflammation has matted the parts unnaturally together, the contraction will be much less. In a case of relapse, operated on a second time by Mr Lucas,³⁴ he found the new insertion of the muscle to be only about $1\frac{1}{2}$ line behind its original attachment. In an eye, dissected by Mr Hewett,³⁵ a month after division of the adductor, the patient having died of phthisis, the muscle had retracted to the distance of $\frac{3}{4}$ inch from its natural attachment, but still remained connected to the eyeball by a strong band of cellular tissue. This band was about three lines in width, and about six

lines in length, and was attached to the eyeball about two lines behind the original insertion of the muscle. In this case, the retraction of the muscle must have surpassed considerably one-fifth of its natural length.

§ 12.—*Unfavourable effects of the operation.*

Some of the unfavourable effects which are apt to arise from the operation are trivial, but others are important.

1. The white cicatrice of the conjunctiva, in the situation of the wound, is of no moment.

2. The eye which has had its adductor divided, presents a greater gap between the cornea and caruncula than natural, the lids appear more open, and the eye more prominent and convex at the nasal angle. This arises from the drawing of the eye forwards by the two oblique muscles, which are no longer perfectly antagonized. If the plan of dividing part of the levator or depressor, in addition to the division of the adductor, were followed, the eye would be particularly liable to project unnaturally.

If both eyes have been operated on, both are rendered more prominent than natural, but being equally so, the circumstance attracts less notice. When only one eye projects, and the projection is great, the physiognomy is very remarkably and disagreeably affected. This affords a reason for operating on the opposite eye, if it presents the slightest degree of strabismus. If we venture to operate on a straight eye, or on one but slightly distorted, for the purpose of equalizing the projection of the two, the tendon should be divided, close to its insertion, and with as little separation of its cellular connexions as possible, for fear of eversion.

3. Whether one eye only or both have been operated on, double vision is not an unfrequent effect. In this case, parallelism of the eyes has not been perfectly restored. If the adductor of one eye has been divided, and the eye is thereby everted in any degree, double vision occurs when the patient looks straight forward, or towards the other side. In general, this effect gradually subsides as the eye recovers the power of adduction, by the action of the inner fibres of the levator and depressor, and the re-adherence of the divided muscle to the sclerotica. The patient should be instructed to look forward at objects, and to avoid looking to a side, especially to the side which increases the double vision, by causing divergence; to the left, for instance, if the right adductor has been divided. Except where each eye, being shaded in its turn, remains straight, tying up one of them only prolongs the evil.

4. One of the most annoying consequences of the operation is extreme eversion of the eye, when the adductor has been divided. Too great a separation of the muscle, and dividing it too far from the cornea, are the causes of this effect; which is still more apt to occur, if, in addition to these causes, the motions of the eye had been previously free and the distortion slight, or if both eyes have been cut. Eversion may also be brought on, soon after the operation, by the patient's looking too much to the side.

Extreme eversion is attended by a disagreeable expression of countenance, giddiness, and such a degree of double vision as unfits the patient for pursuing any employment, and even for walking about, with both eyes open.

The moment the surgeon observes a tendency to eversion, he should caution the patient against turning his eyes much to either side, and especially against such lateral motion as produces divergence of the optic axes; and should recommend him to look always straight before him, and to exercise his eye frequently on near and small objects. If the opposite eye does not become distorted on being closed, it should be bandaged for four or five weeks. If the eversion continues after this, the abductor should be divided. If the eye is inverted after an operation for divergent strabismus, the adductor may require to be divided, should such exercise of the eyes as tends to diminish the convergence, viz. looking forward at distant objects, prove unsuccessful. The division of the antagonist muscle, in either case, will allow the eye to resume its position in the centre of the orbit, and the lateral motions will be performed by the re-adhering muscles, and by the levator and depressor.

The mutual divergence which generally exists in cases of eversion, occurring after division of the adductor, may be remedied by operating on *either* abductor. In a patient operated on by Mr Charles W. G. Guthrie,³⁶ after the adductor of the inverted eye was divided, it gradually became everted. The case was now one of mutual divergence. After some weeks, the abductor of the better eye alone was divided, which cured the eversion of the other eye, without any interference with its abductor. Mr Guthrie's explanation or theory is not satisfactory. He mentions that from a train of reasoning he was led to select the better eye, as an operation on it alone would cure the eversion. This is not the case. The division of the other abductor would with equal certainty have removed the mutual divergence, though objectionable on account of the prominence it would have left from the division of two recti of the same eye.

Alternating eversion, on looking to either side, sometimes follows an operation for convergent strabismus. After division of the adductor of one eye, for example, it has happened that the patient, on looking at any object placed straight before the eyes, directed the axes of both correctly, so that no obliquity could be detected, and vision was single. If, however, without turning his head, he regarded any object placed a little to either side, the eye of that side was instantly everted to a very considerable extent.

In a case of this sort, in which the left adductor had been divided by Mr Duffin,³⁷ when the object was placed to the left side, the eyeball was so much everted that two-thirds of the cornea were concealed in the outer angle of the orbit, the opposite pupil occupying its proper position. When the object was placed to the right side, the right eye was everted in the same manner, while the left remained straight.

In another case, related by Mr Duffin, the same alternating eversion happened after both adductors had been divided. The patient could direct both pupils with the utmost precision, when the object was placed immediately before her; but if it was removed even a few inches to either side, and she continued to look at it without turning her head, the abductor of the eye on the side to which the object was moved, immediately exerted an undue ascendancy, and drew the pupil so much to the outer angle, that vision instantly became double, and a most ungainly cast supplanted the original distortion.

If unfortunately alternating eversion does occur, the same exercise of the eyes as has already been recommended should be followed. Avoid-

ing as much as possible lateral movements of his eyes, the patient should look at small objects placed near and straight before him. In Mr Duffin's cases, the mutually controlling power of the muscles of the two eyes gradually returned, so as to render any operation on the abductors unnecessary.

§ 13.—*Relapse.*

The same general principles, (§ 7), which guide us in operating, or in refraining from operating, on the second eye, and in exercising the eyes immediately after the operation, are to be applied in cases of relapse.

1. It not unfrequently happens, that although the eye, which has been operated on, occupies its proper position immediately after the operation, it becomes occasionally inverted a week or two afterwards. If the inversion is removed by closing the other eye, which in its turn does not become inverted, as is seen on suddenly raising its lid, the good eye must be bandaged, and the other regularly exercised, till the cure is complete and permanent. The same plan is to be followed, if occasional eversion follows the operation, the opposite eye remaining free from any implication.

2. By operating on the worse eye only, its position is sometimes perfectly remedied for the first few days, after which the strabismus is very apt to return to the same eye, although not in the same degree, for the patient is never able to conceal any part of the cornea in the inner canthus, after the division of the adductor. In other cases, the distortion settles in the better eye. The same is very apt to happen in alternating cases, if only one eye has been operated on. Under any of these circumstances, Mr Elliot's plan should immediately be adopted; viz. the division of the same muscle of the second eye, as the surest means of removing the mutual convergence.

If the patient refuses to submit, exercise of the eyes, or what a French critic calls *orthophthalmic*³⁸ practice, must be tried. In such cases, bandaging either eye is useless, as it only substitutes the inversion of the one eye for that of the other, and would confirm the distortion in the eye which was covered. Such exercise as everts the eye which has been operated on for convergent strabismus, seems, at first sight, to be indicated in such cases, and is the practice usually followed; but a little reflection will show that this is the very means to confirm the mutual convergence. Mr Elliot therefore recommends, that the patient should be directed to look to that side which will cause the two eyes slightly to diverge from each other; to the left side, if the right adductor has been divided, and *vice versa*. If the right adductor, for example, has been divided, its incomplete power of inversion will cause the two eyes to diverge a little, when the patient looks fully to the left with the left eye. Mr Elliot calls this *side-practice*, and acknowledges that it would be the most likely plan possible to increase the original evil, were this really, as is too generally supposed, confined to the inverted eye; but urges its success as a strong proof of the truth of his views regarding the mutual affection of the eyes in strabismus.

The cause of relapse has been attributed by some to the muscle re-adhering too soon, and too near its former attachment. To prevent such an occurrence, the eye has sometimes been drawn forcibly outwards, a day or two after the operation, while the adhesions might still be rup-

tured; a very rough treatment, which is not to be recommended. A repetition of the operation has also been had recourse to, on the ground that the abductor, opposed by the re-union of the adductor to the sclerotica, requires a second opportunity of contracting. It is thought that this opportunity will be afforded to it, by again separating the adductor from the sclerotica, and that by this means the cure will be accomplished. That a continued inversion, however, of the same eye, after the first operation, does not depend on any impaired contractile power of the abductor, is evident from the fact, that the patient can not only bring the eye to the central position, before it is operated on, but evert it more or less, on shutting the opposite eye. If the abductor can do this before the adductor is divided, it will be still easier for it to do so, after the operation. The fault, in cases of relapse, does not lie at all in the abductor, but in the reciprocal affection of the two eyes not being overcome, and perhaps not understood.

In repeating the operation, very sharp scissors are necessary to divide the firm cicatrice. The incision of the conjunctiva requires to be free, in order to get through the effused lymph, behind which the muscle is to be exposed. It is more difficult to pass the blunt hook than in a first operation. The parts bleed more, but the reaction is not greater.

If the operation, in the first instance, has been performed according to the rules already laid down, (§ 6), and the better eye operated on as well as the worse, (§ 7), it is not likely that a repetition of the operation will be required in any case.

The only admissible excuse for repeating the operation, would be a conviction on the part of the operator, that he had not separated the tendon completely. The operation may fail, if a slip of tendon, however slight, remains undivided. The operator being satisfied that the operation was complete, he should abandon any idea of repeating it on the same eye, and operate on the other eye, which will both remove the strabismus, and make the eyes equally prominent.

3. Relapse seldom supervenes after both adductors are divided. When it does, Mr Elliot tells us that it is easily removed by exercise. If the relapse affects one eye, and the distortion is removed by closing the other, which does not become distorted in its turn, this eye is to be bandaged till the vision of the eye which had relapsed becomes improved, and parallelism is restored. If the eye which is closed does become distorted, bandaging is useless, and the patient must be directed to practise looking to either side, till the eyes are accustomed to their new association. In a case related by Mr Elliot, in which both adductors were divided, the right eye being the worse of the two, for three days the eyes remained straight. The right eye then gradually relapsed, so that nearly all the white internal to the cornea was concealed, while the patient looked straight forward with the left. In this case, the usual mode of exercising the right eye, by directing the patient to look dextrad, whenever he had an opportunity, was followed by an advantageous result. If the vertex of the retina of the distorted eye is insensible, bandaging the opposite eye would be worse than useless. Side-practice must be tried.

4. In cases of divergent strabismus, in which both abductors have been divided, it sometimes happens that a slight eversion of one or other eye, generally of the worse one, occurs some days after the operation. The patient is to practise looking forward at very near and small objects.

§ 14.—*Orthophthalmic practice.*

Success in curing strabismus depends much on the patient's persevering in well-directed practice.

Three varieties of practice have been referred to in the preceding pages; viz. the *parallel*, the *diverging*, and the *converging*.

1. If, in any case, parallelism can be produced by covering the better eye, it ought to be bandaged, and the other eye exercised. If, by a continuance of this *parallel* practice, the sight of the worse eye is made to equal that of the better, a permanent cure, without operation, will be the result.

After an operation for strabismus, if the distortion relapses, is confined to the distorted eye, and is attributable merely to an effort made by its levator and depressor, parallel practice will be all that is required.

The only effect, on the other hand, of bandaging one eye in cases of distortion involving both eyes, either before or after operation, is reversing the position of the eyes, so that the utmost to be gained by such a practice would be a permanent change of the inversion or eversion from the one to the other, by producing a change in their relative powers of vision.

2. If, after an operation on one adductor, there is any relapse, or renewal of the mutual convergence, as will be shown by inversion of the worse eye, the patient must employ Mr Elliot's *side-practice*, or *diverging* practice. For instance, if the left eye was the worse, and its adductor only was divided, and there is a relapse, let the patient look to his right. By this plan, the inverting power of the left eye is no doubt increased, but the mutual convergence is diminished, and the relapse may be cured. If both adductors were divided, in a case where the left eye was the worse, and there is a relapse, the patient should look to his left, by which means divergence will be produced, as well as eversion of the worse eye.

3. If the case has been one of mutual divergent strabismus, and one or both abductors have been cut, the patient should avoid side-practice, and look at near and small objects, placed straight before him. This is *converging* practice, which is required also in cases of diplopia and eversion after division of one or both adductors. One of the best modes of using converging practice, is for the patient to look frequently at two reflected images, placed at the true concourse of the optic axes, as in Mr Wheatstone's ingenious instrument, called the *stereoscope*.

§ 15.—*Ultimate good effects of the operation.*

The ultimate good effects of the operation refer to the mobility of the eye, and the state of vision.

1. In successful cases, the distortion is permanently removed, the eye occupies its natural position in the orbit, the axes of the two eyes are parallel when distant objects are regarded, and converge equally, and in the proper degree, when the object is near. The motion of the eye is free and uncontrolled. If the case was one of convergent strabismus, the eye does not rest in the centre of the orbit, as perhaps it did immediately

after the operation, but turns naturally to the nose. This movement of adduction is often quite perfect. It is effected by the re-united, or at least re-adherent, muscle, and by the innermost fibres of the levator and depressor.

2. For some time after the operation, the eye cannot be used with much freedom, and this the patient may confound with a new degree of weakness of sight. As the tenderness arising from the wound subsides, the vertex of the retina, which is its most sensitive part, is readily turned towards objects, and the range of vision is increased. A squinting eye often mars the vision of the straight eye, perhaps by the confusion attending diplopia, perhaps by the kind of struggle as to which eye shall be directed on the object, so that the person sees better when the squinting eye is closed; when the operation has been successful in restoring the natural movements of the eye, he sees better with both his eyes open, than he did before when the squinting one was shut.

So far, a decided improvement is effected, and this the patient is apt to mistake for an increase in the acuteness of vision. The fact is, there is never any immediate change in the visual power of the eye, as is ascertained by trying it with the letters of the same printed book with which it was tested before operation. The retinal power never suffers any diminution from the operation, unless in those rare cases where disorganizing inflammation is produced; and in some instances, there follows a considerable improvement in vision. An increase in sensorial power is most likely to follow the operation, where the imperfection has been the effect of the strabismus, the sensibility of the retina having become blunted, and a sub-amaurotic state produced, by disuse. Careful examination shows, however, that the augmentation of sensorial power is seldom great, that it is much oftener fancied than real,³⁹ and that, in general, it would be incorrect to attribute the improvement to any thing else than a return of the power of moving the eyes without restraint, and of directing both of them simultaneously upon objects. This sort of improvement, which is equivalent with the restoration of the very important function of single vision with two eyes, is often very striking, especially when the patient has been successfully operated on for the alternating variety of strabismus.

Patients with convergent strabismus are often myopic. But it would appear, that they sometimes suppose themselves so, merely from their being obliged to bring objects near to their face, in order to see them with both eyes together, so that the whole defect lies in the want of ability to moderate the convergency of the optic axes. After the eyes are restored to parallelism by operation, such patients find that they are not myopic, but see at the ordinary distance.

Convergent strabismus may be so extreme, as to deprive the patient almost totally of the use of sight, till relieved by an operation; but cases of this kind should not be confounded with amaurosis. In a case operated on by Mr Duffin,⁴⁰ the patient was unable to turn the pupils sufficiently towards the centre of the orbit to expose the whole of the cornea to view. Both eyes were liberated by operation at the same sitting, but a considerable time elapsed before the pupils finally attained their proper position. They did so, however, in a considerable degree before the patient left the room. Mr Duffin says, that "she was almost entirely amaurotic before the operation, and recovered her vision, so as

to distinguish small objects, within an hour afterwards ;" but the probability is, that there was nothing really amaurotic in a case where the recovery was so rapid.

¹ Beiträge zur operativen Orthopädie ; p. 22 ; Hannover 1838.

² Heuermann, in his "Abhandlung der neuesten chirurgische Operationen," published at Copenhagen and Leipsick in 1756, says that Chevalier Taylor pretended to cure strabismus by a section of the tendon of the superior oblique. Archives Générales de Médecine, Juin 1841, p. 254.

It is stated by Mr Edwards (London Medical Gazette, vol. xxvi. p. 928,) that Mr Anthony White, senior surgeon to the Westminster Hospital, after dividing the adductor muscle of the eye in several animals, recommended this operation to be tried in the human subject, for the cure of strabismus. On applying to Mr Edwards for farther information on the subject, this gentleman writes me, that, in 1827 and 1828, Mr White frequently recommended, in his clinical observations, this operation as an eligible surgical process, and looked out for squinting animals in order that he might try the effect of the section first on them, before he should apply it to the human subject. When Mr Edwards' letter appeared in the Gazette, he was under the impression that Mr White had actually divided the muscle on animals, but upon application to Mr White he learned that he had gone no farther than recommending the operation in theory.

³ Ammon's Monatsschrift für Medicin, Augenheilkunde und Chirurgie, vol. iii. p. 321 ; Leipzig 1840.

⁴ In illustration of the distinction between inversion or eversion and mutual convergence or divergence, I may mention the case of a patient at present under my care, who is almost blind of the right eye, in consequence of its having been struck with a potato, some months ago. His left eye is incompletely amaurotic, so that he cannot read with it. The left side of his face is slightly paralytic. When he regards an object straight before him, he keeps his eyes turned to the right, so that the right eye is everted and the left inverted ; but he can turn them to the left, and in this movement, their pupils continue at the same distance from one another, so that their axes are parallel. On closing his eyes, and suddenly opening the right, it is always everted ; on suddenly opening the left, it is always inverted. On shutting the left eye, the right becomes central ; on shutting the right, the left remains inverted. In on moving the object sinistrad, the eye becomes central, showing the vertex of the retina to be comparatively insensible. The left eye, therefore, looks sideways at objects ; the right eye does not look at all, but obeys the association of motion. When the left eye is closed, the right occupies its normal place, and uses the little sight it has ; but this it does, only when the left eye is shut. As the eyes are parallel in this case, there is no strabismus. If, by bandaging the left eye, and exercising the right, the right could be made to see better than the left, the patient would look in the natural way.

⁵ Lancet, September 19, 1840, p. 928. Ib. October 31, 1840, p. 192. Ib. December 5, 1840, p. 386. Edinburgh Medical and Surgical Journal, vol. lv. p. 370 ; Edinburgh 1841.

⁶ Lucas's Practical Treatise on the Cure of Strabismus, p. 48 ; London 1840.

⁷ Duffin's Practical Remarks on the New Operation for the Cure of Strabismus, p. 62 ; London 1840.

⁸ Ib. p. 78.

⁹ London Medical Gazette, vol. xxvii. p. 642.

¹⁰ Op. Cit. p. 24.

¹¹ Mémoires et Observations sur l'Anatomie, la Pathologie et la Chirurgie, et principalement sur l'Organe de l'Œil. p. 193 ; Paris 1816.

¹² Dublin Medical Press, March 3, 1841, p. 133.

¹³ Ib. March 10, 1841, p. 148. Dublin Journal of Medical Science, vol. xix. p. 339.

¹⁴ Clay, Lancet, January 2, 1841, p. 496.

¹⁵ Hall, London Medical Gazette, vol. xxvii. p. 284.

¹⁶ London Medical Gazette, vol. xxviii. p. 37.

¹⁷ Die Behandlung des Schielens durch den Muskelschnitt, p. 6 ; Leipzig 1840.

18 Edinburgh Medical and Surgical Journal, vol. iv. p. 376.

19 Lucas, Op. Cit. p. 73.

20 It is well known that when we look at an object straight before us, the pupil is not in the centre even of the aperture of the eyelids, much less of the orbit. The phrase, *centre of the orbit*, is used for the sake of brevity, though not strictly correct.

21 Summary of 76 operations by Mr Liston, Lancet, July 18, 1840, p. 610.

22 Franz, London Medical Gazette, vol. xxvi. p. 690.

23 Lietch, Edinburgh Monthly Journal of Medical Science, vol. i. p. 171; Edinburgh 1841.

24 Ib. p. 178.

25 Op. Cit. pp. 100, 104.

26 In a boy, of hæmorrhagic diathesis, whose life had been in danger several times from hæmorrhage after slight injuries, and who was operated on by Mr Lane, the bleeding continued, with occasional intermissions for six days and five nights, in spite of the usual remedies, both general and local. The prostration was so great that transfusion was had recourse to, and with success. Lancet, October 31, 1840, p. 185.

27 Ammon, Op. Cit. p. 16.

28 Ib. Lucas, Op. Cit. p. 58.

29 Franz, London Medical Gazette, vol. xxvii. p. 41.

30 Lucas, Op. Cit. p. 73.

31 Duffin, Op. Cit. p. 43.

32 Ammon, Op. Cit. p. 15.

33 Commentarii Academiæ Petropolitanæ, tom. i. p. 304; Petropoli 1728.

34 Op. Cit. p. 83.

35 London Medical Gazette, vol. xxvii. p. 654.

36 Report on the Result of the Operations for the Cure of Squinting, performed at the Royal Westminster Ophthalmic Hospital, between the 18th April and 30th October 1840; p. 11; London 1840.

37 Op. Cit. p. 25.

38 *Orthophthalmic*, from ὁρθὸς, *straight*, and ὄφθαλμος, *eye*.

39 Sir Charles Bell's Practical Essays, pp. 77, 78, 82; Edinburgh 1841.

40 Op. Cit. p. 46.

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Erratum in "The Physiology of Vision,"
Page 213, line 8, for "enlarges," read "diminishes."